§15. Development and Irradiation of Optical Components for a Lost Ion Probe

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We sintered the large size of transparent polycrystalline Ce:YAG for the LHD scintillator lost ion probe (LHD-SLIP) and were able to fabricate a diameter of 40 mm and a thickness of 1 mm. Three samples were prepared to optimize the doped Ce density. The light output of Ce:YAG for 0.4, 0.55, and 1.0 mol% was measured, and that of 0.4 mol% decreased to 0.8 of that of the other samples. Therefore we selected the 0.55 mol% Ce:YAG for LHD-SLIP. Figure 1 shows the Ce:YAG scintillator mounted inside the molybdenum probe head of LHD-SLIP. The probe head was attached to the tip of the periscope cylinder. When the LHD-SLIP was located near the plasma boundary, the scintillator temperature was increased from room temperature to ~300 ºC and was piled up during plasma discharges.

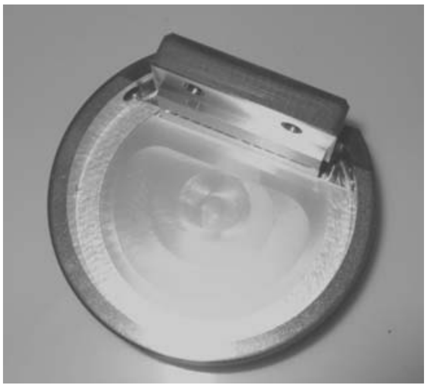

FIG. 1. Polycrystalline transparent Ce:YAG scintillator mounted to the molybdenum probe head of an LHD scintillator lost ion probe.

In the LHD discharge, fast ion losses are measured using the Ce:YAG scintillator. The SLIP is installed from the upper port of the LHD. Fig. 2 shows the typical result of fast ion losses during neutral beam (NB) injection. The pitch angle and the energy of fast ions are measured by an image-intensified CCD camera. The grid for the pitch angle from 90º to 160º and the gyro radius from 2 cm with 1-cm increments is superimposed on the camera image. The fast ions are produced by the counter NB#2, and the pitch angle of lost fast ions changes from the pitch angle of 150º to 120º with the growth of plasmas. The electron density and the electron temperature were 0.5~1x10^{19} m^{-3} and 1~2 keV, respectively.

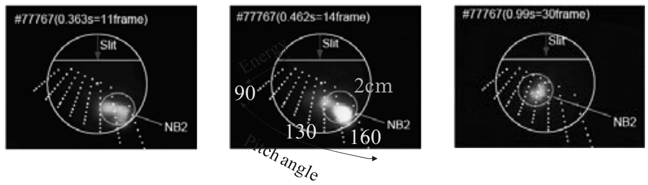

FIG. 2. (Color online). Temporal behavior of fast ion losses during NB#2 heating in LHD discharge. The images correspond to t = 0.363 s, 0.462 s, and 0.990 s, respectively.

The measured spectrum of Ce:YAG had a peak at 560 nm. The light output at peak intensity is plotted as a function of the scintillator temperature in Fig. 3 for Ce:YAG. The H^+ beam with 3MeV energy is irradiated at the beam current of 4.1~4.8 nA for Ce:YAG. The polycrystalline Ce:YAG emits a higher light output than Ag:ZnS at 500 ºC, when the measured light output is normalized by the irradiated beam current. The result is better performance for a lost alpha detector under a high temperature environment. The theoretical curves derived by Lin et al.[1] are plotted as dotted lines, and our theoretical curves are plotted as solid lines. The fitting parameters by Lin et al. are slightly different from ours for both materials. This would be caused by the materials, the impurity contamination, dopant density, grain size, transparency and so on.

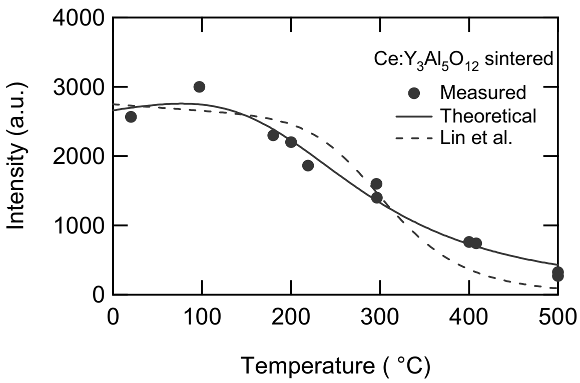

FIG. 3. Characteristics of light output on scintillator temperature for Ce:YAG. The solid curve is the theoretical fitting. The dotted one is the theoretical fitting by Lin et al.

1) Lin, Z., Boivin, R. L., Zweben, S. J., Princeton Plasma Physics Laboratory Report No. PPPL-TM-392, 1992.
2) Nishiura, M., Nagasaka, T., Fujioka, K., Fujimoto, Y., Tanaka, T., Ido, T., Yamamoto, S., Kashiwa, S., Sasao, M., LHD experiment group, submitted to Rev. Sci. Instrums. in 2010.